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ABSTRACT

A non-aversive modification of Bekesy Audiometric Procedures (BAP) used in assessing hearing ability has been found to produce interpretable audiograms from children whose responses to the unmodified BAP were erratic and uninterpretable. In an experiment with six 8-year-old children, three subjects were assigned to a condition in which a light cue was provided that changed in brightness as the auditory stimulus changed in intensity. As a test session progressed, the light was systematically faded until a child had to rely entirely on the test tone. For the remaining three subjects the unmodified BAP were provided. Children receiving visual help learned to monitor and adjust the auditory test stimulus readily and their audiometric records were reliable. Further, when children who produced uninterpretable and erratic results under unmodified procedures were switched to the modified test procedure, their thresholds stabilized. A second experiment with six preschoolers and six third-graders investigated three sequences of stimulus presentation. All sequences produced equally reliable thresholds with the third-graders. Fading the test sound into the light presentation produced the most consistent threshold measurements for the preschoolers. The modification of the BAP offers an improved way to assess the hearing of difficult-to-test persons. Implications concerning auditory attention span are briefly indicated. (Author/RH)

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THE EYES HAVE IT: VISUAL HELP FOR AUDITORY ACUITY

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A reasonable degree of auditory acuity is obviously important for the cognitive and social development of children. It is, therefore, important that a child's sensitivity to auditory stimuli be measureable at an early age. Unfortunately, auditory acuity is difficult to test in very young and retarded children because hearing tests usually require an alert and articulate observer.

Special hearing tests for the retarded are available. Respondent (electrodermal) conditioning techniques that entail presenting a tone along with a prickly shock to the finger, yield valuable but limited types of information on hearing loss. This approach is often cumbersome and unreliable because even mildly aversive shock can generate emotional responses that compete with successful monitoring of the test stimulus. A non-aversive alternative is to pair a tone with the toss of a ball toward a child. On test trials (tone presented alone) a child may indicate she has heard the sound by throwing out her hands into a catching position.

Operant hearing test procedures have also been developed (Lloyd, Reid and Spradlin, 1968). The observer is instructed (guided if necessary) to push a lighted lever when she hears a tone and is reinforced for each lever press in the presence of both the light and tone. The light is then faded, leaving the tone as the only stimulus to be monitored.

Operant techniques have pretty much replaced the less reliable respondent tests. None of the methods developed to date, however, are completely

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satisfactory because they do not allow testing over a wide range of frequencies in a reasonable period of time. In some cases, 50 sessions are needed for the most elementary sort of testing.

The accuracy and speed of sensory measurement can often be improved by allowing an observer to control one or more attributes of the test stimulus. A good example is the Bekesy audiometer on which the examinee monitors and adjusts the intensity of a tone between points of audibility and inaudibility over an extended test session. This has proved to be a very efficient procedure with articulate adults. While the task of attending and responding to a simple tone would not appear to be demanding, it is, in fact, difficult for youngsters and a fair number of adults. For this reason Bekesy type hearing tests have not been used extensively on young and retarded persons.

A training procedure to make the Bekesy technique applicable to younger children was developed by Prince (1971). Observers were presented a compound stimulus of a light and a pure tone along with simplified instructions for the Bekesy technique. When the tone increased or decreased, a light in front of the observer changed in a corresponding but always suprathreshold way. This afforded a visual cue for an auditory change. A study by Miles (1969) indicated that the visual component of a compound stimulus tends to overshadow the auditory component. Fortunately, it has also been demonstrated (Westbrook & Miles, 1970) that when the visual stimulus is faded, the listener can and does rely on the auditory stimulus. In fact, the degree of auditory stimulus control attained in this way is greater then when the auditory stimulus is used alone from the onset of testing.

In the first experiment the modified version of the Bekesy testing technique developed by Prince (1971) was compared with the conventional approach

to Bekesy audiometry. In Experiment 2 various methods of fading the visual and auditory stimuli used in the Bekesy technique were evaluated.

Experiment 1

Observers.

The observers (Os) were six, eight-year-old school children. Os were randomly assigned to either a modified or a conventional Bekesy test condition.

Procedure.

The observers sat quietly in a nearly soundproof room to adapt to test conditions and were instructed as follows:

> I am going to run a test to find out how soft a tone you can hear in your right ear. The tone will start out very low like this (demonstration) and slowly get higher. To make the tone soften and fade away, just hold the key down. To get the tone louder, just take your finger off the key. To help you in judging the tones the light in front of you will brighten like this and dim like this when the tone goes down. After a minute the light will go up and down less and less and then disappear entirely. Try to press down as soon as you are sure you hear the tone and let up as soon as you are sure you can't.

The observers were run for three 9-min. trials per day during eight experimental sessions (over a 2-wk. period). Observers A, B and C were tested with the modified Bekesy technique first and the order of testing conditions was reversed for observers D, E and F.

Tones of 250, 1000 and 4000 Hz were used because: (a) this range covers most of the frequencies involved in speech, (b) tones below 250 Hz are difficult to measure, and (c) hearing losses around 4000 Hz make discrimination between several key phonemes difficult. The order of frequency presentation was counterbalanced over sessions. Pulsed tones were used because they are easier to detect than continuous tones; slow Bekesy attenuation rates were

found to be more effective in the initial stages of training and faster rates better on later trials. Thus the attenuation rates in the first, second and third 9-min. period of each test session were 2, 4 and 8 db./sec.

Results

An audiogram record was considered to start at the second reversal of the recording pen, i.e., after the listener had a chance to hear the test stimulus and reverse the attenuation the first time. The values summarized in Table 1 are the means and standard deviations of the intensities required for tone detection under the various testing conditions. In almost every case tones were detected more consistently at a lower intensity with visual training than without. Visual training was most helpful with 250 Hz tones (those most difficult to detect) and least helpful with 1000 Hz tones (the easiest to detect).

When observers D, E and F shifted to the visual mode their auditory thresholds stabilized to the point where their audiograms were indistinguishable from those of observers A, B, and C. Shifting from the visual to non-visual test mode produced only a small decline in the performance of observers A, B and C.

Experiment 2

The modified Bekesy approach of Experiment 1 was further evaluated using these sequences of stimulus presentation: (I) The test sound and light cue presented simultaneously, followed by fading of the light; (II) The test sound presented alone, the light cue faded in, the light cue faded out; (III) The light cue presented alone, the test sound faded in, the light cue faded out.

Observers.

The observers were six third-graders and six preschoolers. Two third graders and two preschoolers were assigned to each of the three stimulus sequence conditions.

Procedure.

Except for the fading technique the procedure was the same as in Experiment 1.

Results

The means and standard deviations of the intensities required for tone detection are shown in Table 2. The three types of fading sequence produced equally reliable thresholds when the observers were third graders. For the preschoolers, fading in the test sound (Sequence III) produced the most consistent threshold measurements. Apparently the initial success in monitoring the visual stimulus helps pave the way for the more difficult task of monitoring the auditory stimulus.

Discussion

In addition to offering an improved way of assessing the hearing of difficult-to-test individuals, these experiments point up several factors that affect the auditory attention span of young children. First, children clearly find the visual stimulus much easier to monitor than an auditory one. Second, visual help reduces the number and intensity of emotional behaviors that compete with the concentration required for an accurate measure of hearing and, presumably, for other tasks involving sustained listening skills. Finally, the fading in of auditory test stimuli seems to be particularly helpful to preschool age children.

The children in this study were able to follow verbal instructions. However, most of the instruction could have as readily been accomplished by demonstration and guided successive approximations. Thus, the technique appears to be applicable to children with very substantial intellectual retardation.

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Table 1

Effect of Visual Training on the Intensity Required for Tone Detection at Three Frequencies

Hz.	O	Visual sessions		Nonvisual sessions	
		$\bar{X}$	SD	$\bar{X}$	SD
250	A	44	4.9	47	5.7
4000		36	3.6	35	3.8
1000		26	1.7	26	2.2
250	B	48	5.4	52	6.2
4000		33	3.6	37	2.9
1000		20	2.1	21	1.8
250	C	50	5.3	44	4.8
4000		35	2.9	34	3.5
1000		32	2.9	27	3.2
		Nonvisual sessions		Visual sessions	
		$\bar{X}$	SD	$\bar{X}$	SD
250	D	49	9.3	46	5.7
4000		37	7.8	36	3.3
1000		34	6.5	30	2.8
250	E	50	11.2	51	4.3
4000		30	5.3	35	3.9
1000		29	5.1	22	2.1
250	F	52	9.7	40	5.8
4000		37	7.3	33	4.2
1000		36	6.9	19	1.5

Table 2

Effect of Three Fading Sequences on the Intensity Required For Tone Detection at Three Frequencies

Third Graders

Hz	N	Sequence I		Sequence II		Sequence III	
		$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
250	6	48	4.7	54	4.2	46	3.8
4000		36	3.1	38	2.9	35	4.1
1000		33	2.7	24	1.2	24	1.4

Preschoolers

Hz	N	Sequence I		Sequence II		Sequence III	
		$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
250	6	49	6.7	54	5.9	43	3.9
4000		39	5.8	36	4.2	34	3.2
1000		31	3.9	32	4.3	25	1.9